Friction forces key to preventing pipe buckling

FRICTION AND BUCKLING

WE KNOW THAT pipe buckles with friction. In conventional analysis, the only possibility for buckling is to have an initial non-zero lateral displacement, so that the axial force contribution may exceed the fully mobilized friction force. This initial displacement cannot normally be accurately estimated, so the force needed to buckle pipe with sliding friction is essentially unknown.

A cylindrical pipe has another possible mode of lateral displacement. Instead of sliding, the pipe can roll. In this case, the friction force developed is static friction. Static friction may take on any value between zero and the peak static friction value, where the value of the static friction is usually determined from a balance of known forces in the problem of interest. Here, the magnitude of the static friction is determined from a balance of torsional forces on the pipe. The key fact is that the friction force develops gradually, so we may determine a critical buckling force in the traditional sense.

The introduction of axial torque adds further complications to the buckling analysis.

This paper develops a comprehensive model for pipe with axial forces and torque, and then develops the critical buckling loads for two cases of primary interest. Several sample calculations are performed to illustrate the importance of friction forces in the stability of tubing and seafloor flowlines.

The Effect of Friction on Initial Buckling of Tubing and Flowlines (IADC/SPE 99099) RF Mitchell, Halliburton.

99172: At Statoil ASA's Visund field in the Tampen area of the Norwegian North Sea, a full-length, intermdediate-sized 5 7/8-in. drill string was used. Improved ease of running and handling time were among the achievements noted.

WORLD RECORD AT VISUND

Statoil ASA's Visund project is operated from a floating installation located in the Tampen area of the Norwegian North Sea. The Visund field has been developed through 16 subsea completed wells over the past six years. Recently, Statoil ASA set a world record for drilling the longest reach well off a floating installation. Visund's well A 6HT2 was drilled to a measured depth of 9,082m, 822m longer than the Visund A 22 well, which previously held the record. In addition to setting a world record, well A 6HT2 was finished ahead of plan, within budget and set a Visund record for the fastest spud to total depth well with an average rate of penetration of 102m/day.

Compared with the A 22 well, a key technology used on A 6HT2 was a full-length, intermediate-sized 5 7/8-in drill string. Well A 22 used a conventional tapered drill string with several drillpipe sizes. Some of the achievements noted with the intermediate-sized pipe were improved ease of running and handling time, reduced handling tool inventory and maintenance, reduced surface pump pressure and maintenance, reduced drill string weight and a large cost benefit from improved drilling speed.

Achieving this record reach has enabled Statoil ASA to hit targets from the floating installation that were previously thought unreachable.

This paper will present a case history use of 5 7/8-in drill pipe and chronicle the many improvements it allowed so a world record reach could be made. A novel method for ECD reduction in the troublesome 8 1/2-in hole section will also be presented.

Achieving Statoil Visund's World Record Reach With Intermediate Size Drillpipe A Case History (IADC/SPE 99172) WA Ogilvie, RB Chandler, A Devlin, Grant Prideco; HJ Kile, K Rolfsen, Statoil; O Eilertsen, Odfjell Drilling.

STRESS RELIEF BENEFITS

The fatigue performance of HWDP and drill collars cut with and without pin stress relief grooves and API boreback boxes were evaluated using Finite Element Analysis (FEA) and a strain life prediction model. Both NC38 and 6 5/8-in. (6 5/8 FH) HWDP were modeled in various hole curvatures and while buckled in straight hole sections of various hole diameters. Similarly, NC 38 and 8-in (NC56 and 6 5/8 REG) drill collars were evaluated.

The results of the analyses show that stress relief features improve fatigue life significantly and should be included on all HWDP and drill collar components with NC38 and larger connection types. Additionally, heavyweight drill pipe is proven more fatigue-resistant than comparably sized drill collar alternatives.

Conversely, in drill collars, most of the bending occurs in the highly stressed connection. When possible, replacing drill collars with heavy weight drill pipe and eliminating tapered drill collar strings is recommended. The fatigue benefit of stress relief features on HWDP and drill collars decreases as dogleg severity increases or as the hole size in which the components are buckled increases. Although this is true, the stress relief features still provide a significant improvement in fatigue life.

The Effect of Stress Relief Features on HWDP and Drill Collars: Are SRFs Necessary, and When Are They Most Beneficial? (IADC/SPE 98992) SE Ellis, TH Hill Associates.

LINERS IN TROUBLE ZONES

This paper will present rotary liner drilling trial results for Shell where an expandable liner hanger system was used to drill new hole. The technical considerations reviewed are liner connections, liner hanger and packer reliability, torque and drag, and equivalent circulating densities (ECD). Results have been incorporated into future trials.

99065: In rotary liner drilling trials for Shell, an expandable liner hanger system was used to drill new holes. Test results showed it's feasible to successfully drill a liner through difficult formations.

Running liners across depleted or trouble formations in deepwater Gulf of Mexico is challenging. Traditionally, liner running operations across these formations are subject to significant losses or borehole stability issues that increase the difficulty of getting the liner to bottom. Drilling the liner through the trouble zone may reduce these risks. However, some of these practices also have limitations.

In some instances, a mud motor is run, but these are ineffective in low flowrate situations (ECD limitation). Alternatively, the liner maybe drilled in rotary mode but often requires a liner top cement squeeze for zonal isolation, or a two-trip system to run a packer element. These inefficiencies may be reduced by utilizing a one-trip expandable liner system.

Discussion of the trial results covers the first liner drilling attempt, which resulted in a premature liner release. From the lessons learned, a bypass well was drilled, and a second liner drilling trial resulted in successfully drilling new hole.

The liner hanger setting was successful, and the packer held to a positive and a negative test.

Rotary liner drilling trial presented results test provide further evidence that it is feasible to successfully drill a liner through difficult formations.

Rotary Liner Drilling Application in Deepwater Gulf of Mexico (IADC/SPE 99065) JF Mota, DB Campo, J Menezes, Shell; PE Smith, AT Jackson, Halliburton.

INTEGRATED FEA MODELING

Downhole measurement systems have reached an impressive level of accuracy and reliability. The predictive behavior aspect of complete drilling systems, whether it's vibrational or directional, has not, until recently, received the same focus, however. Additionally, cutting structure optimization tends to be confined to: 1) rock strength/type and 2) drive mechanism. These issues have significant cost implications for the operator but in both cases require complex modeling. A system approach is required to achieve true optimization of these two historically separate areas of drillstring design.

Currently available drillstring analysis programs are run from PCs. RAM capabilities limit modeling to only the BHA portion of a drillstring. For the same reason, bit effect factors that significantly influence drillstring behavior are at best assumed.

By utilizing a suite of Finite Element Analysis (FEA) based programs, four-dimensional, time-based simulations of the drilling process are possible.

The system generates the behavior of the entire drillstring, from the cutting edge of the bit to surface. The modeling accurately predicts the vibrations and accelerations often seen to have detrimental effects on directional control, tool reliability, drillstring integrity and drilling performance. This ability to pinpoint the source and effects of torsional, axial and lateral oscillations enables users to qualify design changes to the drillstring configuration and optimize parameters prior to drilling a well. This paper describes Integrated FEA Modeling and descriptive results that have been achieved through its use.

Integrated FEA Modeling Offers System Approach to Drillstring Optimization (IADC/SPE 99018) H Aslaksen, Smith Bits; LC Paez, UT Tran, M Annand, Smith International Inc; RG Duncan, Smith Bits.